INDOOR AIR QUALITY ASSESSMENT

Milton L. Fuller Elementary School
4 School House Road
Gloucester, MA 01930

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
March 2005

Background/Introduction

At the request of the Gloucester Public Schools (GPS), the Massachusetts Department of Public Health (MDPH), Centers for Environmental Health's (CEH) Bureau of Environmental Health Assessment (BEHA) conducted an indoor air quality assessment at the Milton L. Fuller Elementary School (FES), 4 School House Road, Gloucester, Massachusetts. On April 29 and 30, 2004, visits to conduct an indoor air quality assessment were made to the FES by Sharon Lee, an Environmental Analyst in BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) Program. A return visit to inspect the building exterior was made by Ms. Lee and Michael Feeney, Director of BEHA's ER/IAQ Program, on August 4, 2004. The request was prompted by general indoor air quality concerns.

The FES is a two-story brick building originally constructed in the mid-1960s. The school originally was built as a parochial school for boys, but was sold to the City of Gloucester in 1972. At that time, a hallway was built to connect the dormitory to the main school building. Classrooms, a cafeteria, library, computer room, art room, main office, and nurses' offices are located in the main building. The former dormitory now houses administrative offices, as well as pre-kindergarten classrooms. Windows throughout the school are openable.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were conducted with the TSI, Q-Trak, IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers (PM2.5) were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds

(TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID).

Results

The school houses approximately 680 students in pre-kindergarten to fifth grade and approximately 80 staff members. The tests were taken during normal operations at the school. Test results appear in Tables 1 and 2.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were above 800 parts per million (ppm) in 18 of 37 areas surveyed on April 29, 2004, indicating inadequate ventilation in nearly half of the areas surveyed. On April 30, 2004, carbon dioxide levels were elevated above 800 ppm in 2 of 40 areas, indicating adequate ventilation in most areas of the school surveyed on the second day of the assessment. Some rooms were sparsely populated and/or had open windows during these assessments. Both these conditions can reduce carbon dioxide levels.

Fresh air in classrooms is supplied by a unit ventilator (univent) system. A univent draws air from outdoors through a fresh air intake located on the exterior wall of the building and returns air through an air intake located at the base the unit (Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit. Some univents were off at the time of assessments. Obstructions to airflow, such as papers and books stored on univents and items placed in front of univent returns, were also observed in a number of classrooms (Picture 1). In order for univents to provide fresh air as designed, these units must remain activated and allowed to operate while rooms are occupied. In addition, univent intakes and diffusers must remain free of obstructions.

Mechanical exhaust ventilation is provided by wall-mounted or floor level vents powered by rooftop fans. The exhaust system was functioning at the time of assessment; however, obstructions were noted in some areas (Picture 2 and 3). One exhaust vent was also sealed with tape (Picture 4). As with univents, exhaust vents must remain free of obstructions and allowed to function as designed. It is important to note that the location of some exhaust vents can limit exhaust efficiency. In some areas, the exhaust ventilation function is hindered by the proximity of vents to hallway doors (Picture 5). When classroom doors are open, exhaust vents will tend to draw air from both the hallway and the classroom, reducing the effectiveness of the exhaust vent to remove common environmental pollutants. Without sufficient supply and exhaust ventilation, environmental pollutants can build up, leading to indoor air quality complaints.

Mechanical ventilation for common areas (auditorium, cafeteria, etc) and central classrooms (i.e. classrooms without windows) is provided by ceiling- or wall-mounted supply vents connected to rooftop air handling units (AHUs). Air is ducted back to AHUs via wall-mounted return vents. These system were not operating in some areas at the time of assessment.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The last date of balancing was not known at the time of the assessment.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that a room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, see Appendix A.

Temperature readings ranged from 67^o to 73^o F on April 29, 2004 and 66^o to 72^o F on April 30, 2004, which were below or at the lower end of the BEHA recommended comfort range. The BEHA recommends that indoor air temperatures be maintained in a range of 70^o to 78^o F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

Relative humidity measured in the building ranged from 31 to 41 percent on April 29, 2004, which was below the BEHA recommended comfort range in most areas. On April 30, 2004, relative humidity ranged from 41 to 51 percent, which was within the BEHA recommended comfort range. The BEHA recommends that indoor air relative humidity be maintained in a comfort range of 40 to 60 percent. Relative humidity levels in a building would be expected to drop during the heating season. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a common problem during the heating season in the northeast part of the United States.

Microbial/Mold Concerns

Water-damaged ceiling plaster and ceiling tiles were observed in some areas of the school (Pictures 6 and 7). Such damage is an indication of a roof or pipe leak. As reported by school officials, roof problems are related to the roof membrane integrity. Most water damage to ceiling components at the FES is likely related to water penetration around skylights. Water penetrating through skylight panels or the roof membrane has resulted in damage to ceiling plaster and beams (Picture 8). Although water-damaged ceiling plaster is not a source for mold growth, moistened dust trapped in spaces between the paint and brick can become mold growth media. Water-damaged ceiling plaster can be cleaned with an appropriate agent (e.g. bleach and water solution). Water-damaged ceiling tiles can provide a source for mold growth and should be replaced after a water leak is discovered and repaired.

A roof leak was also noted in the stage area of the auditorium. BEHA staff found a wading pool that appeared to be used to collect water. The pool contained stagnant water and debris (Picture 9). The pool should be emptied and cleaned periodically to prevent odor and growth, until measures can be taken to repair/replace the roof membrane.

The American Conference of Governmental Industrial Hygienists (ACGIH) and the US Environmental Protection Agency (US EPA) recommends that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (ACGIH, 1989; US EPA, 2001). If porous materials are not dried within this time frame, mold growth may occur. Cleaning cannot adequately remove mold growth from water-damaged porous materials. The application of a mildewcide to moldy porous materials (e.g., ceiling tiles) is not recommended.

According to school personnel, the FES also experienced flooding in the boiler/basement areas. School personnel reported musty odors in this area. Signs of water damage (e.g., efflorescence) were noted near the entry doorway to the boiler room (Picture 10). Standing water and water-damaged materials were also noted in the boiler area (Picture 11). Standing water and water-damaged materials can serve as a source for microbial growth. Efflorescence was also observed in boiler/basement areas. Efflorescence is a characteristic sign of water damage to building materials such as cement or plaster, but it is not mold growth. As moisture penetrates and works its way through exterior wall, water-soluble compounds dissolve, creating a solution. As the solution moves to the surface of the interior wall, water evaporates, leaving behind white, powdery mineral deposits.

A “damp forest” odor was detected in classrooms 101 to 106. This odor can indicate that excessively damp outdoor air is being introduced into the ground level classrooms of this wing, making classroom materials vulnerable to prolonged moistening. The following may make the wing prone to moisture and odor infiltration:

- Exterior wall configuration: Windows to the FES are recessed from the building frame. Below each window is a “secondary” wall, or curtain wall, onto which water striking the building can roll and drip away from the primary exterior wall (Picture 12).
- Univent design: As discussed, each univent has a fresh air vent located on the building exterior (Figure 1). In most cases, fresh air intakes are located directly on the exterior “primary” wall. As a result of the secondary wall, univents at the FES draw air through an opening between the primary and secondary walls (Picture 12 and 13).
- Wing location: The wing is immediately adjacent to a forested area (Picture 14). The trees and shade provided by the building prevent the sun from drying soil around the exterior wall of the wing. In addition, the ground at the base of the wing was covered with leaves and grass clippings, which prevents soil from drying. If repeatedly moistened, leaves and pine needles can also become mold growth medium.

The location of the wing in conjunction with the design of the building exterior create conditions that likely results in classroom fresh air intake vents drawing in odors and moisture from the areas directly outside and surrounding the building.

Plants and potted soil were located in several classrooms. In some classrooms, plants were found on top of univents and other mechanical equipment (Picture 15). Plants, soil and drip pans can serve as sources of mold growth. Plants should be properly maintained, over-watering of plants should be avoided and drip pans should be inspected periodically for mold growth. Plants should also be located away from ventilation sources to prevent aerosolization of dirt, pollen or mold.

Stagnant water is also a source for microbial growth. Pans with standing water were observed on top of univents (Picture 16). The water in these pans can serve as a source of microbial growth. Moreover, the univent may distribute particles and odors from the water. Similarly, humidifiers and dehumidifiers were noted in some classrooms (Picture 17 and 18). Water reservoirs for humidifiers and dehumidifiers should be cleaned as per manufacturer's directions to prevent microbial growth and odors. The water reservoir for one humidifier had noticeable growth (Picture 17). As with univents, humidifiers can aerosolize particles and odors.

A number of aquariums and terrariums were noted in classrooms (Picture 19). Aquariums should be properly maintained to prevent microbial/algae growth, which can emit unpleasant odors. Similarly, terrariums should be properly maintained to ensure soil does not become a source for mold growth.

Shrubbery and other plants were growing in close proximity to slab walls (Picture 20). The growth of roots against the exterior walls can bring moisture in contact with wall brick. Plant roots can eventually penetrate the brick, leading to cracks and/or fissures in the foundation below ground level. Over time, this process can undermine the integrity of the building envelope, providing a means of water entry into the building through capillary action through foundation concrete and masonry (Lstiburek & Brennan, 2001).

Standing water was noted in a stairwell (Picture 21). Standing water can provide a source for microbial growth and odor production. Pooling water against the building exterior can result in damage to the exterior. Over time, interior portions of the building can also sustain damage.

Lastly, leaves and debris were noted in a subterranean pit (Picture 22). When moistened, this material can also become a source for microbial growth and odor. Leaves should be removed to prevent growth and odor production.

Other Concerns

Indoor air quality can be negatively influenced by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion emissions include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, BEHA staff obtained measurements for carbon monoxide and PM2.5.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

ASHRAE has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from six criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS levels (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide should not be present in a typical, indoor environment. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. On both assessment dates, outdoor carbon monoxide concentrations were non-detect (ND) (Tables 1 and 2). Carbon monoxide levels measured in the school were also ND during both assessment dates (Tables 1 and 2).

The US EPA has established NAAQS limits for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits to particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 micrograms per cubic meter ($\mu g/m^3$) in a 24-hour average (US EPA, 2000a). These standards were adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent, PM2.5 standard requires outdoor air particle levels be maintained below 65 $\mu g/m^3$ over a 24-hour average (US EPA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, BEHA uses the more protective proposed PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were 34 $\mu g/m^3$ and 31 $\mu g/m^3$ on April 29 and April 30, 2004, respectively (Table 1 and 2). PM2.5 levels measured in the school were between 10-27 $\mu g/m^3$ and 17-43 $\mu g/m^3$ (Table 1 and 2). Frequently, indoor air levels of particulates can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulates during normal operation. Sources of indoor airborne particulate may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices, operating an ordinary vacuum cleaner and heavy foot traffic indoors. Operation of ventilation equipment is also important for diluting indoor air pollutants.

Indoor air quality can also be negatively influenced by the presence of materials containing volatile organic compounds (VOCs). VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. An outdoor air sample was taken for comparison. Outdoor TVOC concentrations were ND (Tables 1 and 2). Indoor TVOC concentrations were also ND (Tables 1 and 2).

In an effort to identify materials that can potentially increase indoor TVOC concentrations, BEHA staff examined classrooms for products containing these respiratory irritants. Please note, TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use of TVOC containing products. While no TVOC levels measured exceeded background levels, materials containing VOCs were present in the school.

Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat. Rubber cement containers, which also contains VOCs, was noted. Rubber cement contains n-hexane or heptane, which can be irritating to the eyes, nose and throat. Local exhaust ventilation should be utilized when this material is in use. As required by the federal Labeling of Hazardous Art Materials Act (LHAMA), art supplies containing hazardous materials that can cause chronic health effects must be properly labeled (USC, 1988). The use of such art supplies should be limited to times when students are not present and in areas where adequate exhaust ventilation is available. Rubber cement not only contains VOCs but also is flammable material. Rubber cement should be stored in a flameproof cabinet.

An array of pyrethrin-based insecticides were noted in one room (Picture 23/Table 2). Pyrethrins have been associated with cross sensitivity with individuals who have ragweed allergy (EPA, 1989). Applicators of this product should be in full compliance with the federal and state rules and regulations that govern pesticide use including posting and notification requirements (333 CMR 13.10). Under no circumstances should untrained personnel apply this material. This product should not be applied prior or during school hours. Under current Massachusetts law (effective November 1, 2001), the principles of integrated pest management (IPM) must be used to remove pests in state buildings (Mass Act, 2000). Pesticide use indoors can introduce chemicals into the indoor environment that can be sources of eye, nose and throat irritation.

A number of cleaning agents were also observed in classrooms. Aerosol canisters of "Free with Moly" were noted in some classrooms (Picture 24). This industrial strength product contains TVOCs. Citrus-based agents and other cleaning products were also noted on countertops and in unlocked cabinets beneath sinks in some classrooms (Picture 25). Like dry erase materials, cleaning products contain VOCs and other chemicals that can be irritating to the eyes, nose and throat of sensitive individuals. Also of concern are unlabelled bottles and containers. Products should be kept in their original containers and be clearly labeled for identification purposes, especially in the event of an emergency. In addition, air deodorizers were observed in some classrooms. Air deodorizers can mask any naturally occurring odors, which can indicate problems with the ventilation system or odors migrating from adjacent areas.

A strong odor was detected in classroom 118 during the first day of assessment. At the time of assessment, the univent for this classroom was deactivated. The classroom occupant reactivated the univent in the presence of BEHA staff. The odor was noticeably stronger once the univent was activated. At the conclusion of the first day of assessment, BEHA staff reported the odor to GPS administration and facilities staff. School staff discussed relocating students from the classroom to allow facilities members ample time to dismantle and clean the univent. When BEHA staff returned to complete the FES inspection on April 30, 2004, facilities staff reported two decaying mice were in the univent fan unit.

Pest attractants were identified within the building. Food-based projects and re-use of food containers were noted (Pictures 26 and 27). Proper food storage is an integral component in maintaining indoor air quality. Food should be properly stored and clearly labeled. Reuse of food containers is not recommended since food residue adhering to the surface may serve to attract pests.

Rodent infestation can result in indoor air quality related symptoms due to materials in rodent wastes. Mouse urine contains a protein that is a known sensitizer (US EPA, 1992). A sensitizer is a material that can produce symptoms (e.g., running nose or skin rashes) in sensitive individuals. Since particulate materials can be drawn into an air stream, univents with filters that provide minimal respirable dust filtration can serve to distribute these materials. It is important that proper filters be installed in univents to reduce this potential problem.

A three-step approach is necessary to eliminate rodent infestation:

- removal of the rodents;
- cleaning of waste products from the interior of the building; and
- reduction/elimination of pathways/food sources that are attracting rodents.

To eliminate exposure to allergens, rodents must be removed from the building. Please note that removal, even after cleaning, may not provide immediate relief since allergens can exist in the interior for several months after rodents are eliminated (Burge, 1995). Once the infestation is eliminated, a combination of cleaning and increased ventilation and filtration should serve to reduce allergens associated with rodents.

Several other conditions that can potentially affect indoor air quality were identified. Damaged pipe insulation wrapped with duct tape was observed in one area (Picture 28). The pipe insulation may contain asbestos. The material should be inspected and, if applicable, be encapsulated by a licensed member of the GPS maintenance staff or other licensed professional contractor as soon as practicable.

Accumulated chalk dust was noted in some classrooms. Chalk dust is a fine particulate, which can be easily aerosolized and is an eye and respiratory irritant.

Open pipes and breaches as well as missing ceiling tiles were noted in a number of areas (Picture 29). Open pipes, breaches, and missing ceiling tiles can serve as pathways for dust, dirt, odors and other pollutants to move into occupied areas. A number of exhaust/return vents were noted with accumulated dust. If exhaust vents are not functioning, backdrafting can occur, which can re-aerosolize accumulated dust particles.

Also of note was the amount of materials stored in some classrooms. Items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up. Dust was also noted on fabric partitions. The partitions should be vacuumed periodically to prevent aerosolization when partitions are moved. Dust can be irritating to eyes, nose and respiratory tract.

Inactive birds' nests were observed in some classrooms and reportedly serve as learning props (Picture 30). Birds' nests can contain bacteria and may also be a source of allergenic material. Nests should be placed in resealable bags to prevent aerosolization of allergenic material. These items should also be located away air streams.

Pets were noted in a number of classrooms. Cages are lined with wood shavings and some had accumulated wastes. Porous materials (i.e., wood shavings) can absorb animal wastes and can be a reservoir for mold and bacterial growth. Animal dander, fur and wastes can all be sources of respiratory irritants. Animal cages should be cleaned regularly to avoid the aerosolization of allergenic materials and/or odors.

Lastly, in an effort to reduce noise from sliding chairs, tennis balls had been sliced open and placed on chair legs (Picture 31). Tennis balls are made of a number of materials that are a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and off-gas VOCs. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g. spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as Appendix B (NIOSH, 1998).

Conclusions/Recommendations

In view of the findings at the time of the assessment, the following recommendations are made to further improve indoor air quality:

1. Operate both supply and exhaust ventilation continuously during periods of school occupancy and independent of classroom thermostat control.
2. Continue efforts to educate staff concerning the importance of operating the ventilation system appropriately.
3. Coordinate efforts between GPS maintenance staff and building occupants for reporting and repairing faulty HVAC system components to improve airflow and comfort.
4. Remove all blockages to univents and exhaust vents.
5. Consider having ventilation systems balanced by an HVAC engineering firm every five years.
6. Ensure classroom doors are closed to maximize exhaust ventilation.
7. Adopt scrupulous cleaning practices. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the

day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

8. Replace water-damaged ceilings and repair building materials. Examine these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial. Remove water-damaged materials in a manner consist with *Mold Remediation in Schools and Commercial Buildings* published by the US EPA (2001). This document can be downloaded from the US EPA website: http://www.epa.gov/iaq/molds/mold_remediation.html.
9. Clean debris from grates between the curtain and exterior walls.
10. Examine the feasibility of paving the area around the building to direct water away from the building and to prevent/reduce odor entrainment.
11. Repair/replace the roof membrane and seal breaches around the skylight to prevent further damage.
12. Remove debris and ensure proper drainage in the exterior stairwells and subterranean pits.
13. Move plants away from univents in classrooms. Ensure all plants are equipped with drip pans. Examine drip pans for mold growth and disinfect areas of water leaks with an appropriate antimicrobial where necessary. Consider reducing the number of plants.
14. Clean dehumidifiers and humidifiers regularly to prevent odor and particulate aerosolization.
15. Refrain from using strong-scented materials (e.g. air fresheners).
16. Use the principles of integrated pest management (IPM) to rid this building of pest. Activities that can be used to eliminate pest infestation may include the following activities.
    a) Do not use recycled food containers. Seal recycled containers in a tight fitting lid to prevent rodent access.
    b) Remove non-food items that rodents are consuming.

c) Stored foods in tight fitting containers.

d) Avoid eating at workstations. In areas were food is consumed, periodic vacuuming to remove crumbs are recommended.

e) Regularly clean crumbs and other food residues from toasters, toaster ovens, microwave ovens coffee pots and other food preparation equipment;

f) Examine each room and the exterior walls of the building for means of rodent egress and seal appropriately. Holes as small as ¼" is enough space for rodents to enter an area. If doors do not seal at the bottom, install a weather strip as a barrier to rodents

g) Reduce harborages (cardboard boxes) where rodent may reside.

A copy of the IPM Guide can be obtained at the following Internet address:

http://www.state.ma.us/dfa/pesticides/publications/IPM_kit_for_bldg_mgrs.pdf

17. Remove insecticides from office and classroom areas. Ensure products are stored and used in an appropriate manner.

18. Store rubber cement and household and industrial cleaners in an appropriate manner.

19. Contact a licensed member of the GPS maintenance staff or other professional contractor to assess pipe wrapping as soon as practicable.

20. Seal all utility holes, wall cracks, breaches and any other possible pathways to prevent the penetration of materials and odors into occupied areas.

21. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

22. Consider discontinuing the use of tennis balls on furniture and replacing tennis balls with alternative "glides". Refer to Picture 32 for an example of such glides.

23. In order to maintain a good indoor air quality environment on the building, consideration should be give to adopting the US EPA (2000b) document, "Tools for Schools". This document can be downloaded from the Internet: http://www.epa.gov/iaq/schools/index.html.

24. Refer to the resource manual and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These resources are located on the MDPH's website: http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

References

ACGIH. 1989. Guidelines for the Assessment of Bioaerosols in the Indoor Environment. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

ASHRAE. 1989. Ventilation for Acceptable Indoor Air Quality. American Society of Heating, Refrigeration and Air Conditioning Engineers. ANSI/ASHRAE 62-1989.

BOCA. 1993. The BOCA National Mechanical Code/1993. 8th ed. Building Officials and Code Administrators International, Inc., Country Club Hill, IL. Section M-308.1.1.

Burge, H.A. 1995. Bioaerosols. Lewis Publishing Company, Boca Raton, FL.

Lstiburek, J. & Brennan, T. 2001. Read This Before You Design, Build or Renovate. Building Science Corporation, Westford, MA. U.S. Department of Housing and Urban Development, Region I, Boston, MA

Mass. Act. 2000. An Act Protecting Children and families from Harmful Pesticides. 2000 Mass Acts c. 85 sec. 6E.

MDPH. 1997. Requirements to Maintain Air Quality in Indoor Skating Rinks (State Sanitary Code, Chapter XI). 105 CMR 675.000. Massachusetts Department of Public Health, Boston, MA.

NIOSH. 1997. NIOSH Alert Preventing Allergic Reactions to Natural Rubber latex in the Workplace. National Institute for Occupational Safety and Health, Atlanta, GA.

NIOSH. 1998. Latex Allergy A Prevention. National Institute for Occupational Safety and Health, Atlanta, GA.

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

Sanford. 1999. Material Safety Data Sheet (MSDS No: 198-17). Expo® Dry Erase Markers Bullet, Chisel, and Ultra Fine Tip. Sanford Corporation. Bellwood, IL.

SBAA. 2001. Latex In the Home And Community Updated Spring 2001. Spina Bifida Association of America, Washington, DC. Http://www.sbaa.org/html/sbaa_mlatex.html

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0.

Schmidt Etkin, D. 1992. Office Furnishings/Equipment & IAQ Health Impacts, Prevention & Mitigation. Cutter Information Corporation, Indoor Air Quality Update, Arlington, MA.

SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

U.S.C. 1988. Labeling of Hazardous Art Materials Act. U.S. Code 15 U.S.C. 1277(b)(1).

US EPA. 1992. Indoor Biological Pollutants. US Environmental Protection Agency, Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, Research Triangle Park, NC. ECAO-R-0315. January 1992.

US EPA. 2000a. National Ambient Air Quality Standards (NAAQS). . US Environmental Protection Agency, Office of Air Quality Planning and Standards, Washington, DC. http://www.epa.gov/air/criteria.html.

US EPA. 2000b. Tools for Schools. Office of Air and Radiation, Office of Radiation and Indoor Air, Indoor Environments Division (6609J). EPA 402-K-95-001, Second Edition. http://www.epa.gov/iaq/schools/tools4s2.html

US EPA. 2001. Mold Remediation in Schools and Commercial Buildings. US Environmental Protection Agency, Office of Air and Radiation, Indoor Environments Division, Washington, D.C. EPA 402-K-01-001. March 2001.

Picture 1

Blockages to univent

Picture 2

Obstructions to wall-mounted exhaust vent

Picture 3

Obstructions to floor level exhaust vent

Picture 4

Wall-mounted exhaust vent sealed with duct tape

Picture 5

Exhaust vent located above hallway door

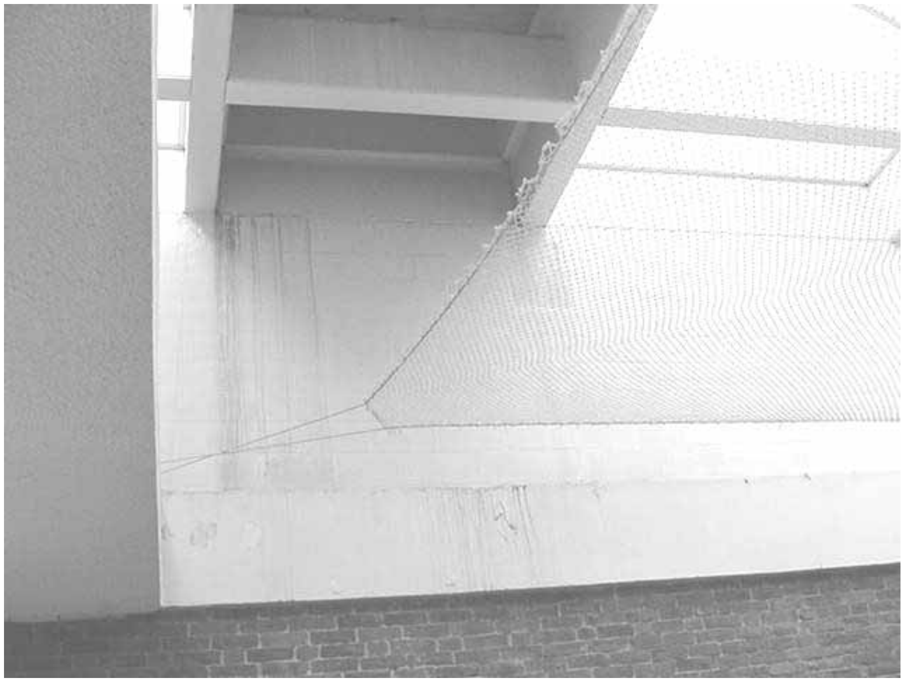
Picture 6

Water damage to ceiling plaster and beams

Picture 7

Water-damaged ceiling tile

Picture 8



Water damage resulting from skylight leak

Picture 9

Stagnant water in pool from roof leak in auditorium, note debris in basin

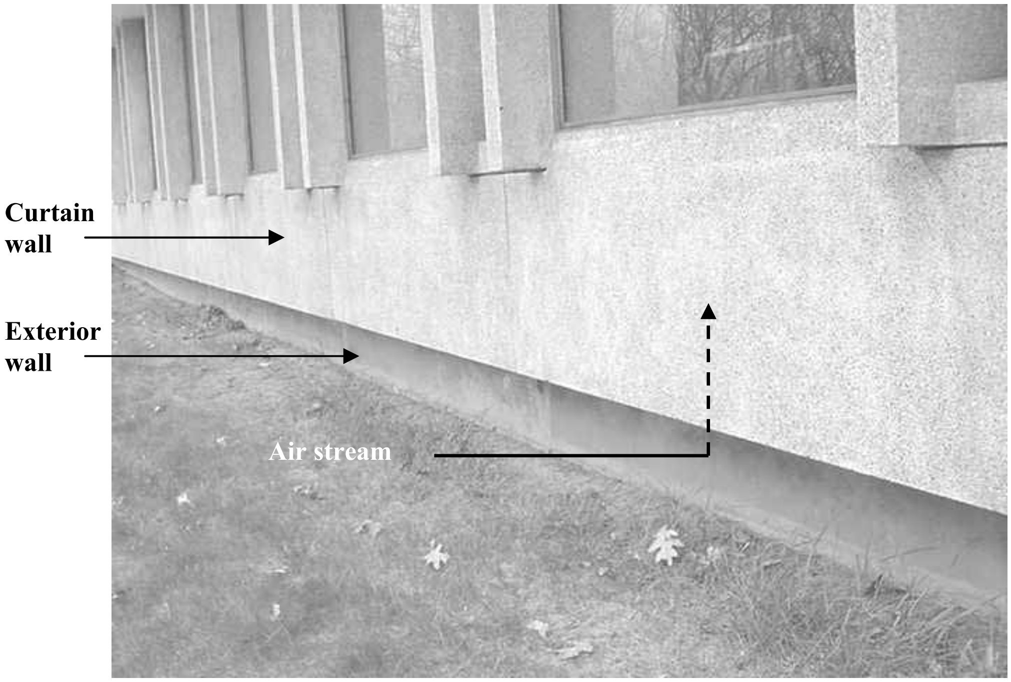
Picture 10

Efflorescence in boiler room stairway

Picture 11

Water-damaged materials

Picture 12



Exterior wall configuration and univent fresh air intake

Picture 13

Space between which fresh air is drawn into univent, grate installed to prevent pest entry

Picture 14

Forest area adjacent to school

Picture 15

Plants on univents

Picture 16

Pans of water on univents

Picture 17

Humidifier, note condition of water well

Picture 18

Dehumidifier

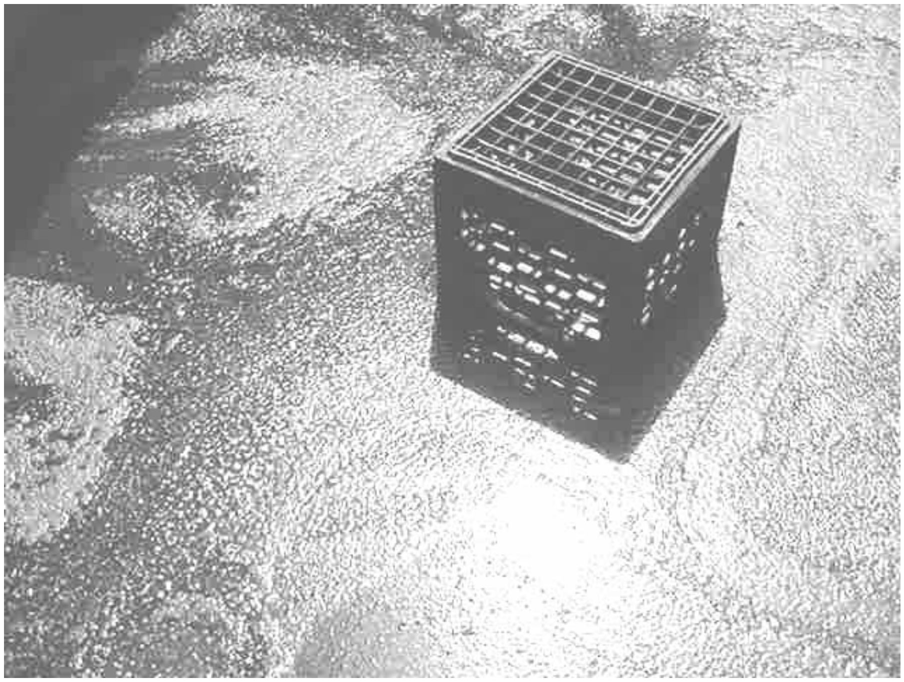
Picture 19

Aquarium, note conditions of water

Picture 20

Plants growth between slabs

Picture 21



Standing water in stairwell, note algal growth

Picture 22

Leaf and debris accumulation in subterranean pit

Picture 23

Insecticides in Office

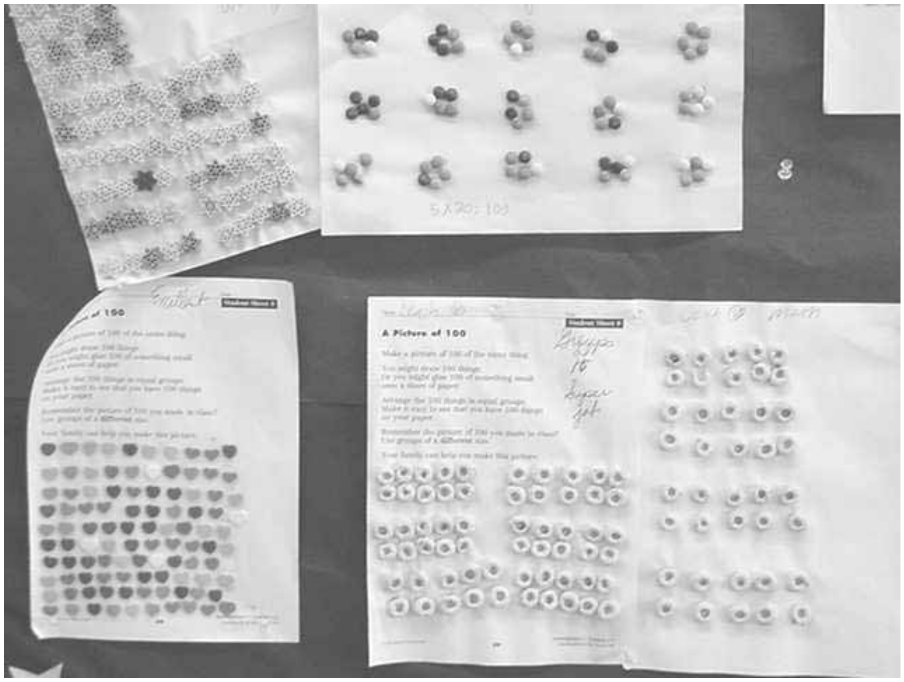
Picture 24

Aerosol canister of industrial cleaner

Picture 25

Cleaners and air deodorizers

Picture 26



Food based projects

Picture 27

Re-use of food containers

Picture 28

Damaged pipe wrapping sealed with duct tape

Picture 29

Open pipe in classroom

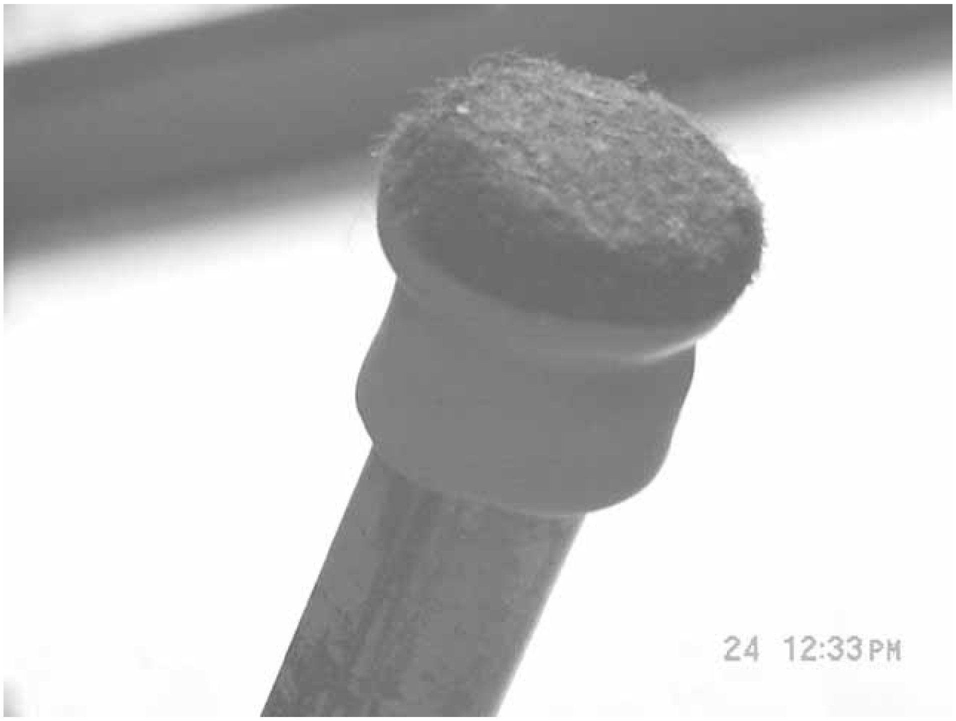
Picture 30

Nests

Picture 31

Tennis balls on chair legs

Picture 32



“Glides” for Chair Legs that can be used as an Alternative to Tennis Balls

Fuller Elementary School | **Indoor Air Results**

4 School House Road, Gloucester, MA 01930 | **April 29, 2004**

Table 1

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
Background	61	49	412	ND	ND	34		-	-	-	Sunny, slight breeze
Library	69	32	550	ND	ND	15	2	Y	Y Univent	Y (weak) Wall	Concerns of musty odors in supply room; Some Univents Off
Computer Room	70	34	860	ND	ND	16	0	Y	Y (1/2 off) Univent	Y Wall	Hallway door open; 27 computers; CD
Title 1 Math	68	34	654	ND	ND	12	0	Y	Y Ceiling	Y Wall	Hallway door open; fridge on carpet; DEM
111	67	37	810	ND	ND	14	5	Y	Y Univent	Y Wall	Univent blocked by clutter, dirt/debris, furniture; CD, DEM, cleaners
113	68	37	710	ND	ND	18	1	Y	Y (off) Univent	Y Wall	Univent blocked by furniture, plants; CD, DEM, cleaners, clutter, FC re-use, food use/storage, plants, standing water in bottles
114	68	40	873	ND	ND	19	18	Y	Y Univent	Y Wall	Univent blocked by clutter, dirt/debris, furniture, plants, cleaners; TB, UF (pillows), FC re-use

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
FCU = fan coil unit
G = gravity
GW = gypsum wallboard
M = mechanical

MT = missing ceiling tile
NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener

PS = pencil shavings
sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Fuller Elementary School | **Indoor Air Results**

4 School House Road, Gloucester, MA 01930 | **April 29, 2004**

Table 1

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
115	68	41	981	ND	ND	15	18	Y	Y (weak) Univent	Y Wall	Hallway door open; TB, cleaners, clutter, plants
116	69	34	884	ND	ND	18	17	Y	Y (off) Univent	Y Wall	Univent blocked by plants, cleaners; Exhaust location; Hallway door open; CD, DEM, cleaners
117	69	38	1014	ND	ND	19	18	Y	Y Univent	Y Wall	Hallway door open; CD, DEM, PF, cleaners, clutter, food use/storage
118	69	38	1230	ND	ND	20	13	Y	Y (off) Univent	Y Wall	CD, DEM, cleaners, clutter, TB; dead animal odor from univent
119	67	35	784	ND	ND	16	9	Y	Y Univent	Y Wall	CD, PC, TB, cleaners, pets
120 (Music Room)	69	35	658	ND	ND	13	21	N	Y Wall		2 CT; CD
201	68	37	1459	ND	ND	12	21	Y	Y Univent	Y Wall	Univent blocked by boxes, clutter, furniture; CD, DEM, TB, clutter

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
FCU = fan coil unit
G = gravity
GW = gypsum wallboard
M = mechanical

MT = missing ceiling tile
NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener

PS = pencil shavings
sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Fuller Elementary School | **Indoor Air Results**

4 School House Road, Gloucester, MA 01930 | **April 29, 2004**

Table 1

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
202	68	38	1872	ND	ND	12	23	Y	Y Univent	Y Wall	Univent blocked by clutter, furniture, plants; Exhaust occluded with dirt/debris; CD, DEM, PS, aqua, cleaners, nests, plants
203	69	37	1454	ND	ND	18	0	Y 1/4 open	Y Univent	Y Wall	Exhaust blocked furniture; Hallway door open; CD, DEM
204	68	36	1471	ND	ND	20	21	Y	Y Univent	Y Wall	Univent and exhaust blocked by furniture; WD-CP; CD, DEM, TB, UF, aqua/terra
205 and 206	67	35	1084	ND	ND	13	21	Y	Y (1/2 off) Univent	Y Wall	Exhaust blocked by clutter; Hallway door open; CD, DEM, aqua/terra, FC re-use
207	67	33	713	ND	ND	11	2	N	Y Wall	Y Wall	WD-CP; CD, PF
208	73	34	1057	ND	ND	15	0	N	Y Wall	Y Wall	Exhaust blocked by furniture; CD, food use/storage
209	67	33	571	ND	ND	15	0	N	Y Wall	Y Wall	CD

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
FCU = fan coil unit
G = gravity
GW = gypsum wallboard
M = mechanical

MT = missing ceiling tile
NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener

PS = pencil shavings
sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Fuller Elementary School

4 School House Road, Gloucester, MA 01930

Table 1

Indoor Air Results

April 29, 2004

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
210	67	37	970	ND	ND	18	2	Y	Y (off) Univent	Y Wall	Univent blocked by clutter, dirt/debris, clutter; Exhaust blocked by dirt/debris, CD, DEM, PS; WD-CP
211	67	36	1160	ND	ND	10	0	Y	Y Univent	Y Wall	Univent blocked by clutter; Exhaust occluded with dirt/debris; Hallway door open; CD, DEM, PS, cleaners, FC re-use
212	68	34	796	ND	ND	15	0	Y	Y (off) Univent	Y Wall	Exhaust occluded with dirt/debris; Hallway door open; CD, DEM, FC re-use, food use/storage, plants
213	68	37	786	ND	ND	13	6	Y	Y Univent	Y Wall	Univent blocked by pans with standing water; Exhaust occluded with dirt/debris; Hallway door open; CD, DEM, TB, clutter, FC re-use
214	68	35	906	ND	ND	18	1	Y	Y (off) Univent	Y Wall	Hallway door open; CD, TB, clutter, FC re-use
215	68	34	610	ND	ND	13	0	Y	Y Univent	Y Wall	Univent blocked by clutter, boxes; CD, DEM, plants

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
FCU = fan coil unit
G = gravity
GW = gypsum wallboard
M = mechanical

MT = missing ceiling tile
NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener

PS = pencil shavings
sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Fuller Elementary School | **Indoor Air Results**

4 School House Road, Gloucester, MA 01930

Table 1

April 29, 2004

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
216	67	33	391	ND	ND	19	0	Y 2/2 open	Y (off) Univent		Univent blocked by boxes; Univent return grill not attached; Hallway door open; CD, DEM, TB, food use as art
217	69	33	479	ND	ND	27	0	Y	Y (off) Univent	Y Wall	Univent blocked by clutter; Exhaust location; CD, DEM, PF, clutter
218	69	32	523	ND	ND	23	7	Y	Y (off) Univent	Y Wall	Exhaust location; Hallway door open; strong perfume; CD, DEM, TB, cleaners, potting soil
219	69	33	598	ND	ND	17	16	Y	Y Univent	Y Wall	Exhaust location; CD, DEM, TB, cleaners, nests, plants
220	69	33	603	ND	ND	19	24	Y 1/2 open	Y Univent	Y Wall	Exhaust location; food art; CD, DEM, UF, aqua/terra, cleaners, clutter, food use as art, plants
221	69	32	512	ND	ND	11	0	N	Y Wall	Y Wall	Exhaust occluded with dirt/debris, location; CD, DEM, plants
222	69	31	490	ND	ND	12	0	N	Y Wall	Y Wall	Exhaust location; hallway door open; CD, DEM

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
FCU = fan coil unit
G = gravity
GW = gypsum wallboard
M = mechanical

MT = missing ceiling tile
NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener

PS = pencil shavings
sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Fuller Elementary School **Indoor Air Results**

4 School House Road, Gloucester, MA 01930 **April 29, 2004**

Table 1

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
223	68	32	525	ND	ND	18	0	N	Y (weak) Wall	Y Wall	Exhaust occluded with dirt/debris; food use/storage
224	68	41	1008	ND	ND	10	16	Y	Y Univent	Y Wall	Exhaust blocked by furniture; DEN, PS, items hanging from ceiling, plants
230 (Art)	68	34	604	ND	ND	13	18	Y 1/4 open	Y Univent	Y Wall	Hallway door open; WD- CP; CD, DEM, cleaners, clutter, dry drain odors, Sharpie marker use/odors; temperature concerns; asbestos concerns, strong odors from oil delivery
231	69	33	513	ND	ND	20	6	Y	Y (1/2 Off) Univent	Y Wall	Univent blocked by furniture; filter change concerns; CD, DEM, cleaners, plants

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
FCU = fan coil unit
G = gravity
GW = gypsum wallboard
M = mechanical

MT = missing ceiling tile
NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener

PS = pencil shavings
sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Fuller Elementary School **Indoor Air Results**

4 School House Road, Gloucester, MA 01930 **April 30, 2004**

Table 2

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
Background	55	47	403	ND	ND	31		-	-	-	Sunny, slight breeze
Assistant Principal's Office	72	42	421	ND	ND	28	0	Y	Y (off) Ceiling	N	Hallway door open; Window-mounted A/C
Assistant Principal's Review Room	72	42	391	ND	ND	27	0	Y	Y (off) Ceiling	N	
Basement/ Boiler room											Sewer back-up
Cafeteria	69	47	458	ND	ND	33	~200	Y		Y (off) Wall	Damaged exhaust louvers; Hallway door open
Computer Room	71	41	609	ND	ND	29	21	Y	Y (1/2 off) Univent	Y Wall	Univent blocked by clutter; Exhaust location; WD-CP; CD, 27 computers

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
FCU = fan coil unit
G = gravity
GW = gypsum wallboard
M = mechanical

MT = missing ceiling tile
NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener

PS = pencil shavings
sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Fuller Elementary School | **Indoor Air Results**

4 School House Road, Gloucester, MA 01930

Table 2

April 30, 2004

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
Counseling	70	46	506	ND	ND	26	1	Y	Y (off) Ceiling		Inter-room door open; orange cleaner odor
Facilities Secretary Office	69	48	439	ND	ND	23	1	N		Y Wall	Hallway door open; dust
Gym (Auxiliary)	68	45	537	ND	ND	24	3	N	Y (weak) Wall	Y Wall	
Gym (Main)	69	43	494	ND	ND	18		N	Y Wall	Y Wall	Exhaust occluded with dirt/debris; Hallway door open
Gym storage	69	40	575	ND	ND	17		N	N	Y (weak) Ceiling	Exhaust occluded with dirt/debris; WD-CP; open utility hole
Main Office	72	44	393	ND	ND	28	1	Y 1/3 open	Y Ceiling		Window-mounted A/C; hallway
Nurse	71	44	385	ND	ND	29	3	Y 2/2 open	Y Ceiling		Hallway door open; window mounted A/C; 1 MT/AT

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
FCU = fan coil unit
G = gravity
GW = gypsum wallboard
M = mechanical

MT = missing ceiling tile
NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener

PS = pencil shavings
sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Fuller Elementary School | **Indoor Air Results**

4 School House Road, Gloucester, MA 01930 | **April 30, 2004**

Table 2

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
OT/PT	67	47	426	ND	ND	19	2	Y	Y Wall	Y Wall	DEM, FC re-use
PT (motor room)	68	45	498	ND	ND	27	0	N	Y Ceiling	Y Wall	Exhaust sealed with duct tape; plastics odor from mats
Special Needs Conference	69	41	602	ND	ND	25	2	Y	Y Univent	Y Wall	DEM, PF, candle
Special Needs Office	69	41	576	ND	ND	27	1	Y	Y Univent	Y Wall	Univent blocked by clutter; Exhaust occluded with dirt/debris, location; Hallway door open; WD-CP; PF, insecticides (roach and ant killer, indoor insect fogger)
Nurse's room 2	71	45	463	ND	ND	28	3	Y 1/1 open	Y (off) Ceiling	N	
101	68	44	498	ND	ND	33	17	Y	Y (off) Univent	Y Wall	Univent blocked by boxes, clutter, furniture, plants; Hallway door open; CD, DEM, TB, cleaners, clutter, FC re-use, food use/storage, plants

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
FCU = fan coil unit
G = gravity
GW = gypsum wallboard
M = mechanical

MT = missing ceiling tile
NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener

PS = pencil shavings
sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Fuller Elementary School

4 School House Road, Gloucester, MA 01930

Table 2

Indoor Air Results

April 30, 2004

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
102	69	45	681	ND	ND	25	18	Y	Y Univent	Y Wall	Univent blocked by clutter, furniture; exhaust blocked by clutter, occupant noted water penetration from exhaust vent; standing water; terra, cleaners, clutter, FC re-use, food use/storage, plants
103	69	46	587	ND	ND	43	17	Y	Y (off) Univent	Y Wall	Univent blocked by boxes, clutter; Exhaust blocked by boxes, clutter, furniture; hallway door open; DEM, cleaners, clutter, FC re-use; temperature complaints (cold)
104	68	45	544	ND	ND	9	0	Y	Y (off) Univent	Y Wall	HEPA-AP; CD, DEM, humidifier; "Free" container; slight musty odor
105	68	47	593	ND	ND	30	13	Y 1/4 open	Y (off) Univent	Y Wall	Univent blocked by clutter, furniture, plants; Exhaust blocked by clutter, boxes, furniture; plants, "Free" container; slight musty odor
106	68	510	786	ND	ND	27	21	Y	Y Univent	Y Wall	CD, DEM, cleaners, clutter; moss odor
107	68	45	427	ND	ND		0	N	Y (off) Wall	Y Wall	Hallway door open

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
FCU = fan coil unit
G = gravity
GW = gypsum wallboard
M = mechanical

MT = missing ceiling tile
NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener

PS = pencil shavings
sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Fuller Elementary School

4 School House Road, Gloucester, MA 01930

Table 2

Indoor Air Results

April 30, 2004

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
108 (lounge)	67	46	801	ND	ND	27	0	N	Y Wall	Y Wall	Exhaust blocked by clutter; Hallway door open; clutter, FC re-use, food use/storage
109	66	47	692	ND	ND	32	5	Y	Y (off) Univent	Y Wall	Univent blocked by boxes, clutter, furniture; Exhaust blocked by clutter, furniture; Hallway door open; CD, DEM, clutter
110	66	42	551	ND	ND	26	0	Y	Y (off) Univent	Y Wall	Univent blocked by furniture; Exhaust blocked by boxes, clutter, furniture; CD, DEM, PF, TB, clutter
111	68	44	797	ND	ND	23	3	Y	Y Univent	Y Wall	Univent and exhaust blocked by clutter and boxes; CD, DEM, cleaners, clutter, TB; FC re-use, food use/storage; occupant reported fine coating of dust on univent during winter
112	68	42	871	ND	ND	20	0	Y	Y Univent	Y Wall	Hallway door open; CD, DEM, cleaners, FC re-use; food use/storage; plants
121	69	43	706	ND	ND	18	18	N	Y Wall	Y (weak) Wall	CD, PS, plants
122	70	43	641	ND	ND	22	2	Y	N	N	Hallway door open; dust

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
FCU = fan coil unit
G = gravity
GW = gypsum wallboard
M = mechanical

MT = missing ceiling tile
NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener

PS = pencil shavings
sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Fuller Elementary School | **Indoor Air Results**

4 School House Road, Gloucester, MA 01930 | **April 30, 2004**

Table 2

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
123	68	47	793	ND	ND	30	9	Y	Y Univent	Y Ceiling	Breach between sink/counter; 1 MT/AT; TB, cleaners, clutter, FC re-use, food use/storage, plants; car exhaust odors, occupant reports welding odors when work is conducted outside
124 (inner)	68	46	462	ND	ND	31	0	Y	Y Ceiling	Y Ceiling	Exhaust occluded with dirt/debris; CD, TB, clutter, FC re-use, food use/storage, pets
124 (outer)	68	47	521	ND	ND	31	16	N	Y Ceiling		Sandbox, CD, clutter, FC re-use, food use/storage
124 (play room 1)	68	46	502	ND	ND	31	0	N	Y Wall	N	CD, polish odor
124 (play room 2)	68	45	472	ND	ND	29	0	N	N	Y Wall	Inter-room door open; CD, DEM, TB
127	66	47	392	ND	ND	27	0	Y	Y Wall	Y Wall	

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
FCU = fan coil unit
G = gravity
GW = gypsum wallboard
M = mechanical

MT = missing ceiling tile
NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener

PS = pencil shavings
sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Fuller Elementary School **Indoor Air Results**

4 School House Road, Gloucester, MA 01930 **Table 2** **April 30, 2004**

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
128	70	44	404	ND	ND	24	0	Y	Y Univent	Y Floor	Exhaust blocked by clutter; breach sink/counter; UF, cleaners, clutter, FC re-use, food use/storage, pets
129	67	44	392	ND	ND	22	0	Y	Y Wall		Inter-room door open; WD-WP, WD-CP; CD
129 kitchen	67	47	381	ND	ND	22	0	Y 1/1 open	Y Wall		Hallway and inter-room door open; 4 WD-CT, WD-CP, TB, food use/storage
130	68	44	419	ND	ND	22	0	Y	Y Univent	Y Wall	Univent blocked by clutter; Exhaust occluded with dirt/debris; Hallway door open; CD, DEM, PS, cleaners, FC re-use

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
FCU = fan coil unit
G = gravity
GW = gypsum wallboard
M = mechanical

MT = missing ceiling tile
NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener

PS = pencil shavings
sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%